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COSMIC RAY ASTRONOMY

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The cosmic ray division participation in the cooperative agreement was activated in the second year. The scientific goals will be analysis of cosmic ray data from the Japanese-American Cooperative Emulsion Experiments (JACEE). Measurements of primary cosmic rays in the JACEE emulsion chambers will be made to derive for each detected particle the deposited energy in the chamber and the primary charge (atomic number). The data will be corrected to the primary flux above the atmosphere, and the composition and energy spectra will be derived. The spectra of the individual elements will be interpreted in context with the supernova shock and other models of cosmic ray acceleration.

Elemental Abundance of High Energy Cosmic Rays by Antarctic Balloon Flight Experiments. The UAH JACEE team in collaboration with the NASA/MSFC team has carried out a series of balloon flight experiments to explore the elemental composition of these high energy nuclei for the first time, directly measuring the primary charges and energies with emulsion chambers. We performed (1) detector designing, (2) emulsion materials production, (3) balloon flights, (4) post-flight processing, (5) photometry and scanning of events, and (6) cosmic ray event tracing in the detector. At high energies above 100 TeV/n ($\sim 5 \times 10^{15}$ eV for Fe), a spectral break (- Knee -) has long been recognized by the Extensive Air Shower (EAS) observations. Interstellar and supernova shock acceleration mechanisms encounter a great theoretical difficulty at this very energy region. Experimental data were, however, limited to the indirect energy flow spectrum and the data on the elemental abundance were missing. The JACEE group's balloon flight experiments with emulsion chambers has landmarked the first direct measurements of cosmic rays at the critical high energy region. Very high energy spectra of cosmic ray nuclei have been analyzed. From a total of 12 balloon flights, with an exposure factor of about 580 square-meter hour, the world's largest to date, the energy spectra of cosmic ray nuclei have been obtained in the energy range from several TeV to 1,000 TeV. The proton energy spectrum extending to several times 100 TeV showed a single-power law with some deficiency of statistics above 50 -

100 TeV. The helium spectrum is consistent with a single-power law in the energy range from 2 TeV/n to 200 TeV/n. Other nuclei up to Fe indicated harder spectral indices compared with those of protons and helium. The particle composition at around 500 TeV is $16 \pm 5\%$: $29 \pm 5\%$: $35 \pm 5\%$: $9 \pm 3\%$: $11 \pm 4\%$, for the abundance of $p : \text{He} : \text{C} \sim \text{O} : \text{Ne} \sim \text{S} : \text{Z} > 17$.

A Graduate Research Assistant (Mr. Surasak Phengchamnan) was supported under the UAH portion of Cosmic Ray during the time period February 1999 - February 2000. Mr. Phengchamnan's research effort was directed by Dr. Geoff Pendleton. The Monte Carlo simulation of the Advance Cosmic-Ray Composition Experiment for the Space Station (ACCESS) was used to study its response characteristics. The main objective of ACCESS is to measure high energy cosmic rays. The simulation results involved proton interactions at a very high energy. Response functions for ACCESS were generated in the 100 GEV to 3TEV energy range for protons. Nonlinear models were fit to the lateral dispersion of the energy deposition in the ACCESS detector planes for prototype event characterization and total event energy estimation. Energy resolution estimates were made using several different combinations of the model parameters fitted to events.

The USRA activities are included in a separate report which is submitted as a sub-contract report.

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SPACE PLASMA PHYSICS

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Dr. James L. Horwitz and R. Hugh Comfort's studies with the high altitude TIDE data have been progressing well. We concluded a study on the relationship of polar cap ion properties observed by TIDE near apogee with solar wind and IMF conditions. We found that in general H^+ did not correlate as well as O^+ with solar wind and IMF parameters. O^+ density correlated best with the solar wind dynamic pressure, solar wind speed, E_{sw} , $V_{\text{sw}}B_{\text{IMF}}$, and K_p . At lower solar wind speeds, O^+ density decreased with increasing latitude, but this trend was not observed at higher solar wind speeds. By comparing these results with results from other studies of O^+ in different parts of the magnetosphere, we concluded that O^+ ions often leave the ionosphere near the foot point of the cusp/cleft region, pass through the high-altitude polar cap lobes, and eventually arrive in the plasma sheet. We found that H^+ outflows are a persistent feature of the polar cap and are not as dependent on the geophysical conditions; even classical polar wind models show H^+ ions readily escaping owing to their low mass. Minor correlations with solar wind drivers were found; specifically, H^+ density correlated best with $\text{IMF } B_y$, $V_{\text{sw}}B_{\text{IMF}}$, and E_{sw} . These results were presented to the Spring AGU Meeting [Elliott et al., 2000a]; and a paper on this investigation has been accepted for publication in the *Journal of Geophysical Research* [Elliott et al., 2000b].

Currently we are carrying out a detailed examination of observations on April 19, 1996 when the solar wind velocity was high and Alfvén waves were present in the solar wind. We have found similar large scale features in the solar wind velocity, IMF B_x , polar cap ion outflow energy of both O^+ and H^+ , polar cap magnetic field fluctuations, and electrons precipitating in the polar cap. The high activity and the electron spectrum suggest that a 'polar squall' formed. The large amounts of O^+ , and the linear relationships found between polar cap data and the solar wind data mentioned above all lead us to conclude that the solar wind is driving a parallel electric field on the order of tens of volts in the polar cap, which in turn drives the polar ion outflows.